DRILLING IN THE YUKON

Presented to

The Whitehorse Board of Trade

"NORTHERN RESOURCES CONFERENCE"

By

W. G. Campbell

March 20 - 22nd 1963

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ABSTRACT

Drilling in the Yukon Territory has very few problems that are different from drilling a wildcat well in other parts of the world. With the exception of the effect of perma-frost on ground conditions during the summer months and on the drilling of surface hole, drilling conditions as encountered in the Eagle Plain area can be duplicated in other areas.

It is the supporting relative activities and operations such as geophysics and freighting and other undertakings that take on unique aspects because of their being done in the Yukon. The extreme changes in the weather conditions experienced in the northern Yukon are a very important part of the planning of such supporting activities and contribute a great deal to the added time and expense necessary in undertaking oil and gas exploration.

The Eagle Plain area of the northern Yukon is a large sedimentary basin containing thick sections of sedimentary rock. The presence of promising structures has been indicated by geophysical and surface geological surveys and two deep exploratory wells have been drilled, one of which, Western Minerals Chance No. 1, encountered encouraging flows of both oil and gas.

It is estimated that approximately a minimum of $50,000,000. will be invested in the northern Yukon before it is known whether economical deposits of oil or gas do exist.

The future for oil and gas development in the Yukon is based on a long term investment. Quick returns on initial investments is not one of the attractions of the Yukon. However, there is reasonable optimism with respect to the orderly and economic development of oil and gas in the Yukon, and the North as a whole.

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W.G. Campbell

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DRILLING IN THE YUKON

By: W.G. Campbell

In 1952 the first Federal Government Oil and Gas Reservations were issued on approximately 6,000,000 acres situated in the Yukon and Northwest Territories straddling the Arctic Circle. At that time Western Minerals Ltd. was not active as an operator in the north country, however, subsequently did obtain an interest in these lands as a partner with Conwest Exploration Company. Through the years Western Minerals acquired a 100% interest in the lands and have been, until recently, the sole operator and owner of all lands as remain from the original holdings, now approximately 4,3000,000 acres of oil and gas permits.

The subject area is roughly 225 miles north of Dawson City, 450 miles from Valdez on the Alaskan coast, and 200 miles from the Beaufort Sea on the northern coast. Initially, interest in the oil and gas possibilities in this area was raised by exploration parties of the Geological Survey of Canada and it was through their recommendations that the two initial reservation blocks called the Eagle Plain (Western) and Peel (Eastern) were put up for tender.

It was noted by these Government survey parties that the Eagle Plain area in particular was a tremendous sedimentary basin and with indications that sizable thicknesses and structures were present which might yield, on drilling, large accumulations of oil and gas.

Geological reconnaissance, magnetometer and gravimeter surveys, extensive seismic activities, and the drilling of two deep test wells have been undertaken by Western Minerals and associates on Eagle Plain and Surrounding areas since 1952. Most of this activity has been concentrated in the Eagle Plain area and it is therefore to this area that I will confine my remarks.

Geologically speaking, Eagle Plain is an intermontane basin with mountain ranges on three of its borders and a near range on its fourth. It is 85 miles wide and 125 miles long. The beds forming the flanking ridge of Eagle Plain dip basinward at low angles. Eagle Plain is drained by the Porcupine River and its tributary streams. The region is unique in being one of the few localities in northern Canada that does not exhibit either glacial deposition or glacial erosion.

As mentioned, Eagle Plain is a sedimentary basin. Strata from Precambrian to Tertiary in age are to be found. Studies have shown that facies changes occur in several geological units and unconformities are present in the stratigraphic column. Buttressing and overlap of various formations occur across Eagle Plain.

The more significant geological units encountered have been the Precambrian, Lower Paleozoic, Mid and Upper devonian, Upper Paleozoic, and Mesozoic (including Jurassic and Cretaceous rock).

It is significant to note that practically all members included in this geological column have exhibited possible reservoir and/or hydro-carbon generating characteristics, and the fact that substantial quantities of oil and gas were found in the Western Minerals Chance No. 1 Well, presumably in the Pennsylvanian formation, has supplied a very encouraging boost to oil and gas exploration in the general Eagle Plain area. To indicate some idea of the potentialities of oil and gas accumulations that are present in this area, thickness of the sedimentary strata vary from some 15,000 feet on the edges of the basin near the mountain uplifts to thirty thousands of feet thick in the more central portions of the basin.

A cross-section drawn north-south through the Eagle Plain area shows the large thicknesses of sedimentary rocks that occur and the undulation of the formations show promise of major structural formations being present -- factors that oil geologists get excited about. The east-west cross-section shows similar characteristics.

To determine just how large and where these sub-surface

structures were in the area considerable seismic and other geophysical programs have been completed. As a result, several have been indicated, and two of them have been tested by deep drilling.

For example, the contours shown on this map outline by seismic interpretation a structure which gives some idea of the extent of one of those features. It has an aerial dimension of 9,000 square miles and closure of 3,000 feet. This initially had all the ear-markings of a very interesting prospect. In drilling Eagle Plains No. 1, interpretations of seismic and geologic data were almost entirely confirmed however, there was one thing lacking, and that was the presence of oil and/or gas in the structure.

Discouraging as this was, there are indications of similar structures, and, as those in the business know, many "dry" wells are often drilled in similarly favourable areas before an oil or gas discovery is made. The second well, Western Minerals Chance No. 1, was a discovery and, while details of its success are presently confidential, I can say that the structure on which it was drilled was separate from the Eagle Plains location, and the geologic column which the well penetrated was, for the most part, in rocks of younger age than those encountered in Eagle Plains No. 1.

This year it is planned to drill a third well approximately twelve miles straight west of Western Minerals Chance No. 1.

My preceding remarks are not given solely for the purpose of establishing a historical background, but also to indicate that there is more to drilling a well than just placing a drilling rig on the ground some-where and proceeding to make hole forthwith. Months and, many times, years of investigation are necessary before a well location can be picked. For example, as a matter of interest, let us follow through the logical sequence of steps which may be required before actual drilling takes place.

Initially, geological, gravimeter, magnetometer and seismic programs are laid on before drilling is considered. These activities are planned according to the seasons of the year, especially in the Yukon Territory where differences between winter and summer conditions are so great. Generally speaking, geologic operations are restricted to those months in which the surface is bare of all snow; in other words, for the most part, June, July and August. Gravimeter and magnetometer surveys can be undertaken over a wider range of the year but, being dependent upon the support of helicopters, are restricted to those months these machines are operative. Then, finally, seismic surveys also are limited to certain periods, a point I will deal with shortly as a separate item. These are by no means the only restrictions placed on such activities. Supplies, mostly fuel and food, etc., must be located or cached in convenient spots previous to any of them being undertaken; this isfor the reason that no ground freighting of any consequence is possible during the summer months, and the placing of these supplies is done during the winter season. There are exceptions to this, of course, but in general this statement is true. Therefore, the problem of freighting supplies to a work area is actually the first activity to be considered, and it in itself is restricted by the limited period in which freighting operations are feasible.

The limitations placed upon the freighting season are caused by the necessity of the surface of the ground to be sufficiently frozen to withstand heavy loads. From previous experience this period runs from the first of January to approximately mid-April. So, therefore, in trying to program even initial exploratory activities which are to be undertaken in the summer months, preparations must be made six months ahead so that freighting operations can be organized and undertaken during the winter months.

It would be unreasonably optimistic to expect that in all instances a seismic operation, or any other type of exploration, could yield sufficient data in one season from which a well location could be chosen. For instance, let us look at a seismic survey.

For a seismic undertaking in the Eagle Plain area a surface peration requiring vehicles capable of transversing the terrain with as uch mobility as possible is desired. This relates directly to surface onditions which again are restricted to the time of the year in which hese conditions are suitable. Using the most modern equipment, especialy designed for northern operations, it was found that the best period ithin the year to operate a program of this kind is during the months f March, April and May. Before March freighting is necessary to provide upplies for the operations and after May the surface conditions are such hat the seismic operations are extremely limited and are not advisable rom then on. (This is caused by the continual melting of the ice within the perma-frost during the summer months and the terrain becomes very ough and water saturated and is not conducive to an efficient ground peration.) It can be done, but with definite limitations and with ncreased costs.

Now let us jump a few hurdles and assume that the seismic, ravimeter and/or magnetometer, and geological surveys are complete nd the drilling location has been decided upon. To make this decision t was necessary in the first instance to analyze and interpret all the easons' data, a time-consuming job. If the field work is completed by he first of June of any year, then it will most likely be the year-end efore recommendations to drill can be made, and this brings one up to ecember of the year, or a full year after freighting for the seismic rogram itself was initially started.

This example is based on the best of conditions and favourable esults with the least amount of effort, therefore it would represent minimum period of time. Actually two seasons of surface geological ork followed by two seasons of seismic interspersed with gravimeter and agnetometer surveys, totalling four years of endeavour, were completed efore sufficient data was gathered to make a drilling choice. Now the eal work began.

After the decision to drill the Eagle Plains No. 1 Well was eached in 1956 we undertook to purchase and completely outfit a drilling ig, a complete tractor train, and all the supplies required from Edmonton, ancouver and Whitehorse, and to freight the more than 3,000 tons nvolved 300 miles from Flat Creek north to our first drilling location, agle Plains No. 1.

The freighting equipment included eight International Harvester D-24's, one TD-18, four TD-14's and forty freighting sleighs. In ddition, two D-7 Caterpillar tractors were leased. Capable personnel o operate the tractor train had to be employed, and this was done through ur Whitehorse office. I would like to mention at this time that freightng of this equipment and supplies to the well location appeared in 956-1957 to be an almost insurmountable problem, let alone what lay head in the actual drilling of the hole once the freighting of the rill rig and supplies was completed.

Since those first days the problems of freighting have eased omewhat because: firstly, with each year we became more experienced nd therefore more adept at the operation; and secondly, because of the ssistance afforded to us with the construction by the Federal Governent of a truck route from Flat Creek to Chapman Lake. However, in pite of these improvements, freighting still remains one of the major asic costs for any operation undertaken in the northern Yukon and coninues to be an operation restricted by the fact that it can be underaken beyond the limits of truck roads only during the winter months.

As mentioned before, once drilling commences in the Yukon, he problems presented are not too different than those experienced in ther parts of the world. However, there are a few points which are ifferent and are worth mentioning.

The Eagle Plain is underlain completely by perma-frost which aries in thickness from approximately five hundred feet to 1,500 feet eneath the surface. Perma-frost, for the purposes of this discussion, ill be defined as that sub-surface material, whether consolidated or nconsolidated, whether rock or vegetation, remaining permanently below

32° Fahrenheit. Because of the presence of this perma-frost in the north Yukon districts certain precautions have to be taken in the setting up of a drilling rig and in the drilling of the initial surface hole. Because of the seasonal limits placed on freighting, it is very likely that drilling will proceed through the warm months of the season during which time the top two or three feet of the earth's surface melts. Fortunately, the whole area is covered by a blanket of insulation placed there by nature which, for the most part, consists of moss, but also growing are various types of grasses and trees. As long as this vegetation is not disturbed only the very top part is subject to melting. If this naturally placed insulation is removed the silty soils, which are primarily water-laden, are exposed and the rate of melting of the surface increases and therefore the conversion of ice to water is accelerated. This, in turn, causes the water to flow more freely, tearing away more surface material, causing more silt to be exposed to heat, and more ice to be melted. In very short order a minor trickle no bigger than your finger can become a major water course too large to cross by standard means.

Now, in the process of erecting a drill rig it is very necessary that a firm platform be constructed upon which the rig is to be placed. This is usually a simple operation where perma-frost does not exist; but where it does, special procedures have been followed. To ensure a stable base a plank platform supporting the rig is placed on wooden piles. Thirty-two 1 -inch diameter piles were placed under the rig sub-structure and one hundred or more 8-inch piles were placed beneath the mud tanks, pumps, as well as the boilers and other heavy equipment. The manner in which this is done is comparatively simple.

Using a seismic rig and drilling with air, 12-¼ inch holes are drilled for the 10-inch piles to an average depth of around eighteen feet. Nine-inch holes are drilled for the 8-inch pilings. After the holes are drilled the pilings are dropped into them and water or mud is then poured into the space between the pile and the hole. Almost immediately the piling is frozen in firmly, quite capable of supporting the drill rig's weight winter and summer. The piles are levelled, capped and covered with two layers of 3-inch planking with building paper between. A generous supply of moss, harvested like hay from the surrounding countryside, is placed around the piles to afford some degree of additional insulation. The expense is not great and the results are guaranteed.

It has been estimated from various tests undertaken over the past few years that the temperature of the perma-frost is only a few degrees below 32° Fahrenheit and therefore does not interfere too much with the normal process of drilling or running and cementing of casing. However, there have been, and continue to be difficulties encountered in drilling the initial surface conductor pipe hole in unconsolidated material. For the most part, bed-rock below unconsolidated material is fairly shallow, from thirty to a few hundred feet below the surface. It is this particular surface material which causes the problem, usually consisting of silty overburden containing up to eighty percent water and, in some instances, lensed with layers of pure ice. Conventional drilling mud systems are therefore very inadequate in making the conductor pipe hole in that the warm drilling mud quickly melts the ice and produces in a rapid fashion very large and sometimes uncontrollable cavities. This causes conditions of lost circulation in which there are no mud returns, normally expected with the drilling of a surface hole, and the circulating fluids may come out any place on the surface, sometimes many feet distant from the hole being drilled.

To date there has been no real solution to this problem. In all cases the conductor pipe hole has been drilled to the required depth and the drilling fluid is allowed to flow where it may. One solution to this problem would be to drill the conductor pipe hole with compressed air, as is done with piling holes; however, as the conductor pipe hole diameter is usually twenty to twenty-four inches a very large volume of air would be required, calling for elaborate compressor equipment. It is very doubtful that the cost of freighting in the compressor equipment required to drill conductor pipe holes, plus the cost of purchasing or of leasing such equipment, would result in an

economical safeguard. However, the use of air or natural gas in drilling would be worth considering if an extensive drilling program were ever proposed for air or gas could probably be used for drilling hole below the surface casing as well.

The conductor pipe is used to control circulation of drilling mud and usually, once cemented into place, no further problems are encountered. It is, however, advisable to set one or two thousand feet of surface casing for at this depth the casing would probably be within solid rock where a good anchor for cementing is probable.

Other than these points mentioned, no outstanding difficulties occur in the actual drilling of a well in the Yukon that do not occur in many other parts of the world.

A few observations about the actual drilling may be of interest. In both cases of the wells, Eagles Plains No. 1 and Western Minerals Chance No. 1, one and one-half years elapsed before completion. However, in actual drilling time, seven months were required to reach the total depth of 9,600 feet at Eagle Plains No. 1, and eleven months for Chance No. 1 to 8,600 feet, this latter time including two months of production testing. It is quite possible however that a well may be drilled to 10,000 or 12,000 feet in one year once the rig and supplies are on the location. Western Minerals drilled to a medium depth during the first drilling season and waited for the following freighting season to take in supplies to deepen each well.

The hole size and casing program that was adopted is typical for wildcat drilling. The plan called for, in addition to the conductor pipe, 2,000 feet of 13-3/8" surface casing, 5,000 feet of 9-5/8" intermediate casing and 10,000 feet of 5½" production casing. Drilling rates, including all times such as trip times, coring and testing, and down time for repairs, etc., averaged between fifty and fifty-five feet per day. We may have endeavoured to core and test more of the zones than would be expected in most similar drilling programs. It seemed good sense that after having spent so much money in preparing for drilling there was no point in trying to save relatively small sums of money by passing up any possibility of porosity or of oil and gas occurring in the formations.

With the information and knowledge we now have of the geologic columnar section of the Eagle Plain area, such diligent drilling may not be required and drilling times could therefore be substantially decreased.

Hardness of the rock drilled varied widely with the softer drilling occurring in the shallower horizons and the medium to hard conditions occurring at lower levels. The hole deviation was kept in strict control, limiting the variations from vertical to only a few degrees.

Drilling mud used was the standard bentonite type with the usual additives such as viscose, caustic, tannex, carbonex, etc. being used when necessary.

In the first well drilled we had a minor lost circulation problem. In the second well we had a mud weighting problem due to a high pressure gas zone. In both instances mud supplies were depeleted rapidly and an air lift operation had to be organized to keep the well under control and the well drilling ahead. To indicate how much of an increase in the cost of drilling this may initiate; bags of Aquagel and/or Baroid cost about $4.00 per 100 pound bag F.O.B. Fort St. John, B.C.; by the time this 100 pound bag was flown from Dawson City to the nearest lake, then transferred by helicopter to the wellsite, the cost of he bag of mud increased to $40.00.

Other than these points mentioned, no outstanding difficulties occur in the actual drilling of a well in the Yukon that do not occur in many other parts of the world.

General remarks as to the costs of drilling a well in the ukon can be misleading,only by detailed analysis can the costs directly

attributed to the fact that the well is or was drilled in the Yukon be ferreted out. However, a few overall figures may be interesting to present.

Total costs of drilling are between a million and a half to two million dollars for each deep test, a deep test being anywhere from eight to twelve thousand feet. Twenty-five percent of this total is chargeable to freighting; 45 percent to direct operating costs; 20 percent to special services such as air services, communication, etc.; and 10 percent to special studies, insurance, overhead, consulting fees, etc. Putting it another way, direct costs or operating costs are approximately $100 per foot, and the total costs around $200. per foot.

Seismic operations cost approximately $500. per profile or $90,000.to $100,000. per month.

An average small geologic survey, three months in length, would require a budget of $50,000. to $60,000.

During the last ten years, approximately twenty million dollars have been invested in the Yukon solely in the search for oil and gas. Not one red cent of return has been realized as yet--nor was it really expected. However, within the next five to ten years some definite indications should be apparent as to whether there are to be returns of significant nature and within that five to ten years an additional fifteen to twenty million dollars will likely have been invested. It is not unreasonable therefore to envision an expenditure of close to fifty million dollars in the exploration for oil and gas in the Yukon before it is even known if economical deposits of these hydrocarbons do exist. Such is the risk involved in the oil and gas business.

In summary, I would like to quote from an article I wrote for the Canadian Geographical Journal.

"Oil and gas exploration has been, and is presently being, successfully undertaken in the Northern Yukon Territory, but with more difficulty, and therefore at a greater expense, than comparative operations conducted on the plains of Western Canada. The economic incentive is considered on a long term basis with initial investment being great but with a reasonable expectation that oil and gas will be developed in sufficient reserves to result eventually in exploratory and development costs being at least competitive with, if not less than, other oil-producing countries. It is not anticipated that this point will be reached, even assuming the reserves are there to be found, for many years. A quick return on initial investments made is not one of the attractions of the Yukon. In fact, the initial high cost of oil and gas exploration, plus some hesitancy in accepting present regulatory policies has, for the time being at least, reduced the interest. Regions of immediate potentialities are receiving most of the attention from exploration companies today.

"The consensus of opinion, however, of most companies is one of reasonable optimism with respect to the orderly and economic development of oil and gas in the Yukon and the North as a whole. New techniques and equipment are reducing costs year by year and the ingenuity of man to meet seemingly unsolvable situations will be seen again meeting the challenge of this isolated land. Many new applications of atomic power, electronics and other scientific achievements are already waiting to be used beneficially. Oil is now in oversupply in world markets, but men eminently qualified to give an opinion have predicted that present consumption and future demands will increase steadily. In basing their conclusions on known world reserves, they represent them as being 'alarmingly inadequate'. It would therefore seem quite reasonable to conclude that although the stakes are high in the search for oil and gas in the Yukon, that there is a reasonable and fair chance that the rewards will be great and long lasting."

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